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ICP Waters Report 148/2021
Biological intercalibration: Invertebrates 2021

Foto: Christian Lucien Bodin

International Cooperative Programme on Assessment and Monitoring Effects of Air Pollution on Rivers and Lakes

Convention on Long-Range Transboundary Air Pollution

LRTAP
Long-range Transboundary Air Pollution

Norwegian Institute for Water Research

REPORT

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Summary

The 25th biological intercalibration of invertebrates in ICP Waters included three participants. The intercalibration is important for harmonizing taxonomic work across countries, to ensure high quality data in the ICP Waters database and to increase the taxonomic skill of the participants. The laboratories correctly identified a high proportion of the specimens in the test samples. In total points, they achieved 97.0 % on identifying species and 99.3 % on genus. The mean Quality assurance index (Qi) ranged from 93.3 to 97.4. No laboratory had a mean value below 80, which is the limit for acceptable taxonomic work.
The intercalibration under the ICP Waters programme was the first regular test of species level identification. Here, we present trends in the intercalibration of invertebrates from the initial intercalibration in 1992 up to the present. The average number of participating laboratories is 4.75. The results show that the Qi has remained above 80% for the full period, suggesting skilled taxonomists in the laboratories affiliated to ICP Waters.

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CONVENTION OF LONG-RANGE TRANSBOUNDARY AIR POLLUTION

INTERNATIONAL COOPERATIVE PROGRAMME ON ASSESSMENT AND MONITORING EFFECTS OF AIR POLLUTION ON RIVERS AND LAKES

Biological Intercalibration: Invertebrates 2021

Prepared at the ICP Waters Programme Subcentre
NORCE AS
Bergen, December 2021

Preface

The International Cooperative Programme on Assessment and Monitoring of the Effects of Air Pollution on Rivers and Lakes (ICP Waters) was established under the Executive Body of the UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP) in July 1985. Since then, ICP Waters has been an important contributor to document the effects of implementing the Protocols under the Convention. ICP Waters has prepared numerous assessments, reports and publications that address the effects of long-range transported air pollution.

ICP Waters and its Programme Centre is chaired and hosted by the Norwegian Institute for Water Research (NIVA), respectively. A Programme subcentre is established at NORCE, Bergen. ICP Waters is supported financially by the Norwegian Ministry of Climate and Environment and the Trust Fund of the UNECE LRTAP Convention.

The main aim of the ICP Waters programme is to assess, on a regional basis, the degree and geographical extent of the impact of atmospheric pollution, in particular acidification, on surface waters. More than 20 countries in Europe and North America participate in the programme on a regular basis.

An objective of the ICP Waters programme is to establish and maintain an international network of surface water monitoring sites and promote international harmonization of monitoring practices. A tool in this work are inter-laboratory quality assurance tests. Here biases between analyses carried out by individual participants of the programme are identified and controlled. The tests are also a valuable tool for taxonomic discussions and the exchange of identification keys among the participating laboratories, thereby improving the taxonomic skill.

Here we report the results from the 25th intercalibration of invertebrate fauna. We also compare results from all 25 intercalibrations.

Bergen, December 2021

Gaute Velle
ICP Waters Programme Subcentre

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Summary

The 25th biological intercalibration of invertebrates in the ICP Waters programme included three laboratories. The intercalibration is important for harmonizing taxonomic work across countries and is of high value in programmes where the focus is on community analyses, e.g., for the classification of ecological status according to the EU Water Framework Directive. The intercalibration under the ICP Waters programme was the first regular test of species level identification and has run annually since 1992.

The laboratories correctly identified a high proportion of the specimens in the test samples. In total points, they achieved 97.0 % on identifying species and 99.3 % on genus. The mean Quality assurance index ranged between 93.3 and 97.4. No laboratories had a mean value below 80 – the limit for acceptable taxonomic work.

We also present trends in biological intercalibration of invertebrates from the initial intercalibration in 1992 up to the present. The average number of laboratories that took part on each occasion was 4.75. The results show that the quality assurance index has remained above 80% for the full period, suggesting skilled taxonomists in the laboratories affiliated to ICP Waters. When the Qi is broken into individual invertebrate groups, it is clear that the laboratories, on average, perform best for caddisflies (Trichoptera) and worst for stoneflies (Plecoptera). The mean Qi was lower between 2015 and 2017. According to the taxonomists that participate in the intercalibration, the decline in quality may mostly be due to an increase in difficulty.

1 Introduction

The purpose of the biological intercalibration of invertebrates is to evaluate the quality of the biological data delivered to the Programme Centre. The data are used nationally and by ICP Waters to indicate environmental conditions from the species and their tolerances (Raddum et al. 1988, Fjellheim and Raddum 1990, Raddum 1999, Velle et al. 2013, 2016). The significance of potential trends in biotic indices, both for a specific site/watershed and for comparisons of trends among regions or among countries, can be evaluated once the data quality is known. The data are also used in numerical analyses (Larsen et al. 1996, Skjelkvåle et al. 2000, Halvorsen et al. 2002, Halvorsen et al. 2003), and in analyses of biodiversity (Velle et al., 2013, Velle et al. 2016). The results from such data analyses are especially sensitive to the quality of the species identifications. The biological intercalibration focuses on the taxonomic skills of the participants and is a tool for improving the quality of work at the different laboratories, as well as harmonization of the biological database.

The methods for the intercalibration of biological material were outlined in 1991 at the seventh ICP Waters Task Force meeting in Galway, Ireland. The countries/laboratories must know their native fauna. Since the fauna vary according to geographical regions, it is necessary to prepare specific samples for each participating laboratory, based on their native fauna. We cannot use standardized samples for all participants. Therefore, each laboratory sends identified samples of invertebrates from their own monitoring sites to the Programme subcentre. The Programme subcentre adds species known to be present in the region of the specific laboratory. Based on this, each laboratory receives individual test samples composed of species representing their own monitoring region. Each participant is therefore tested on their ability to identify taxa that should be familiar to them.

The taxonomic skill of the participants is measured by using a quality assurance index (Raddum 2005). This index evaluates the skill of participants when identifying species and genera. It also considers the effort of identifying all specimens in the sample. The highest index score is 100, while a value of 80 is set as the limit of good taxonomic work.

This report mostly adheres to a similar format that has been used in previous reports and contains text partially or completely retained from previous reports (Raddum 2005, Fjellheim et al. 2014, Halvorsen et al. 2016, Velle et al. 2018).

2 Methods

Preparation of the test-samples

Samples of invertebrates were sent from all participating laboratories to the organizer at the ICP Waters subcentre. These samples were used to compose test samples, with the addition of specimens from earlier exercises and from collections at the subcentre. The test samples included caddisflies (Trichoptera), stoneflies (Plecoptera), mayflies (Ephemeroptera) and miscellaneous.

Miscellaneous included water beetles (Coleoptera), crustaceans (Malacostraca), leeches (Hirudinea), mollusks (Gastropoda), dragonflies (Odonata), water boatmen (Corixidea), midges and flies (Diptera), butterflies and moths (Lepidoptera) and true bugs (Heteroptera). Both larvae and adults were included. Leeches, mollusks, and crustaceans are sensitive to acid water and important for the evaluation of acidification. The tolerance of some miscellaneous species is poorly known. They are often regarded as tolerant to acidic water and of low importance for the evaluation of acidity. They are still important in invertebrate community analysis.

The geographical distribution of the taxa was checked using the Fauna Europaea Web Service 2013 (http://www.faunaeur.org). This is a database of the scientific names and distribution of multicellular European land and fresh-water animals (see example in Figure 1).

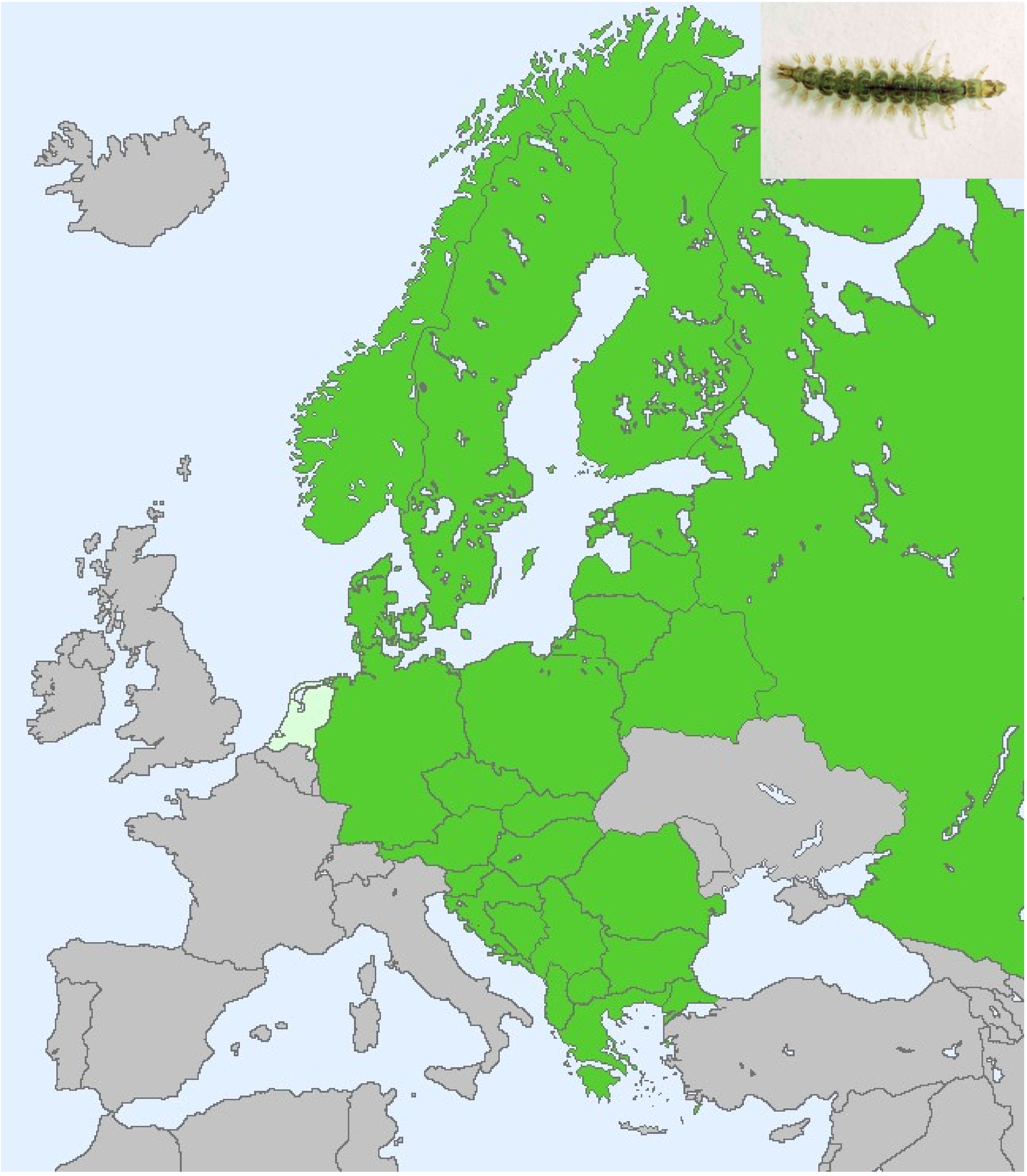

Figure 1. Geographical distribution of the caddisfly *Rhyacophila nubila* in Europe. This species is widely distributed but is absent from several West-European countries. Map after Fauna Europaea Web Service, http://www.faunaeur.org, Photo: Arne Fjellheim

Identification

To minimize possible faults, the following procedure was used in preparing the test samples:

- The participating laboratory first identified the source material for the test samples and shipped the specimens to the organizer.
- Two persons from the organizing institution verified the identification of the specimen as far as possible without damaging the individuals.
- The content of two test samples per participant was listed in a table. Two persons controlled that the correct numbers and species were placed in the test samples according to the table.

Damage to the material

The quality of the test material may be reduced during handling and shipping. Taxonomically important parts of the body, such as gills, legs, cerci and mouthparts can be lost or damaged during identification, handling and transportation. Mixing of individuals between samples may occur during identification. All above mentioned examples are source of errors that could influence the process of identification and verification of taxa negatively, and thereby the end results.

Evaluation

The participants were invited to comment on the results before the report was published. In this way, we removed potential bias - for example misidentification caused by damaged test material. In cases of disagreement between the participant and the organizer, the material may be checked again by the organizer. This procedure may act educational for both parts.

For calculation of errors, we took into account possible degradation of the material. Further, a misidentified species counted as only one fault, even if the sample includes many individuals of the species. We encouraged participants to give comments on matters that may impede the identification. For example, a misidentification will not count as a fault if a specimen lacks important taxonomic characters. Such comments must be made before the results are sent to the organizer.

We have discriminated between short-comings in identification, probably due to damaged material, and true errors (wrong species – or genus). Due to this, some subjective evaluation of the results was made. The number of errors is therefore subject to some degree of expert judgement.

The organizer also noted how many specimens a participant has identified per sample. This is called *percent identified*. A low percent means that many individuals were not identified and will consequently reduce the value of the taxonomic work.

In cases where more specimens were identified than sent to the laboratories, each excess specimen counted as one error.

Available material for making test samples vary. Normally, each laboratory receives between 60 and 130 species in the two samples. Samples with low diversity are easier to handle than samples with high diversity (see Appendix B). This should also be kept in mind when the results are evaluated. Small samples were avoided, as only a few misidentifications could result in a low score.

According to Fauna Europaea (http://www.faunaeur.org), the total number of European mayfly (Ephemeroptera), stonefly (Plecoptera) and caddisfly (Trichoptera) species (in 2015) is 1814. However, the biodiversity differs between countries. Generally, the number of species decreases along a gradient from Southern to Northern Europe. This is also a fact to bear in mind when judging taxonomical capacity. As an example of this, the freshwater fauna of Switzerland is much richer than in Norway and Sweden – even though the area of Switzerland is approximately 1/10 of the two Nordic countries (Figure 2).

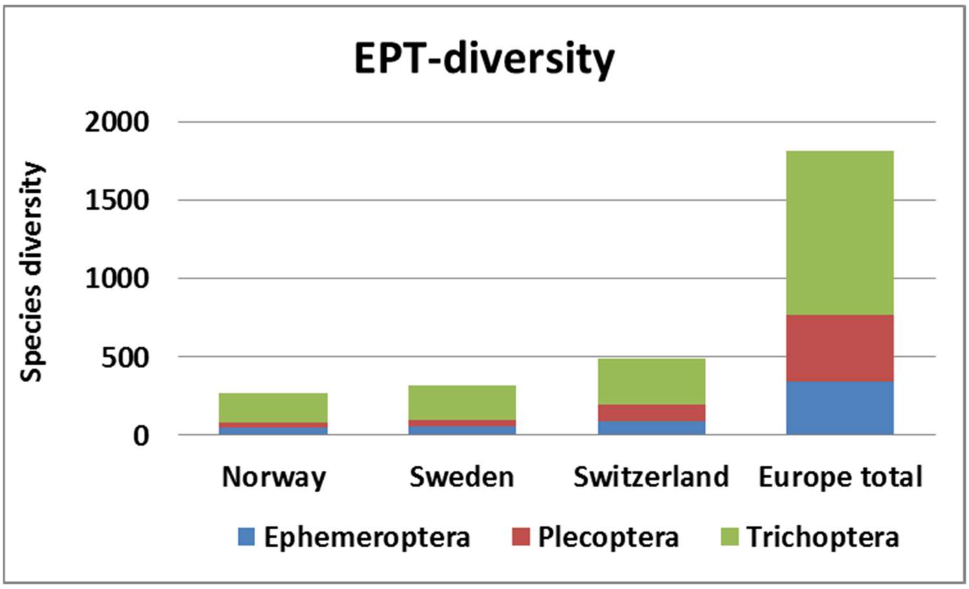

Figure 2. Species diversity of mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera) in Norway, Sweden and Switzerland (after Fauna Europaea Web Service, http://www.faunaeur.org).

Quality assurance index

We have calculated the Quality assurance index, Qi, for important groups of invertebrates as well as the mean index for each participant. The Qi integrates the separate levels of the identifications as follows:

Qi = (% correct species/10) * (% correct genus/10) * (% identified individuals/100)

Qi will be a number between 0 and 100 with increasing skill. A score ≥ 80 is regarded as good and thus acceptable taxonomical work.

Test of the subcentre

The ICP Waters subcentre in Bergen is tested with the help from the Swedish participant every second year. The Swedish University of Agricultural Sciences in Uppsala prepares and evaluates the test of the subcentre. Methodology and implementation are otherwise identical to the other tests.

3 Results and discussion

Two laboratories and three taxonomists participated in the intercalibration of invertebrates in 2021 (Appendix A). The species lists and the identification results are shown in Appendix B, Tables B.1-B.3. Samples of invertebrates sent to laboratory 1 were delayed in the mail and a second batch of samples was sent and identified. Eventually, the initial sample was received and was identified by a different taxonomist in the laboratory. Both samples are included in this report and are represented as laboratory 1a and laboratory 1b according to the order of when they were initially sent. In one of the samples sent to be randomized, a species of trichopteran had been misidentified. Following the test after the randomization of the samples they correctly identified the species giving the laboratory half a point for the identification.

Mayflies (Ephemeroptera)

The identification of the mayflies (Figure 3) was flawless for laboratory 1b with no misidentifications. Laboratory 1a and 2 both misidentified a single individual at species level. However, Qi-score results were still well above the acceptable limit (80) for both laboratory 1a and 2.

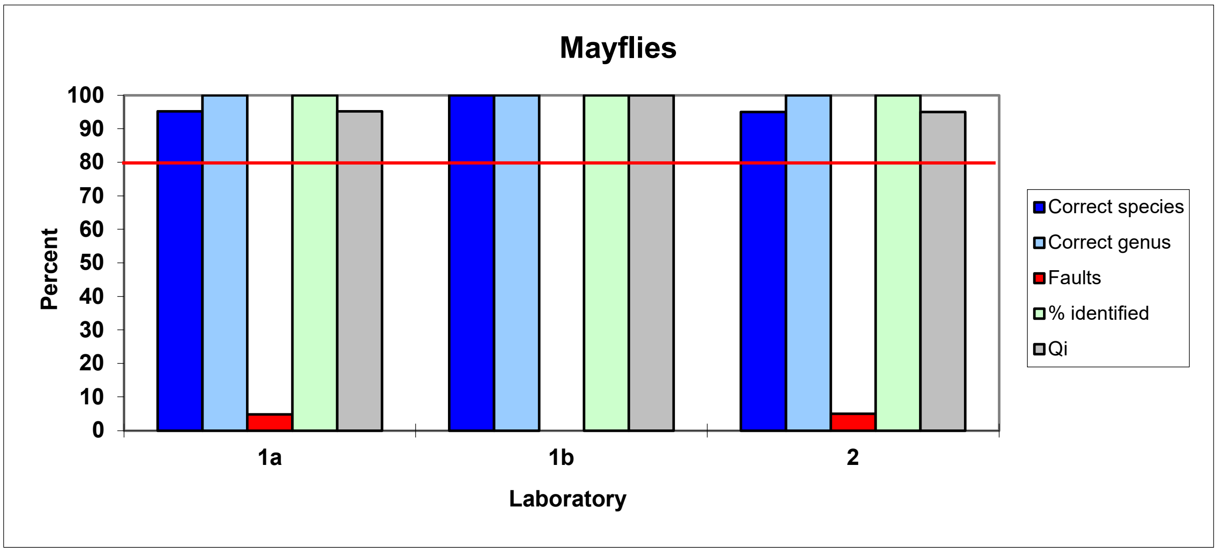

Figure 3. Results from the identification of mayflies. The red line indicates the limit for good taxonomic work.

Stoneflies (Plecoptera)

Results for the identification of stoneflies are shown in Figure 4. Lab 1a misidentified two genera subsequentially also two species, 1b misidentified one species, while laboratory 2 failed to identify the species of one single individual. All results were above the acceptable limit.

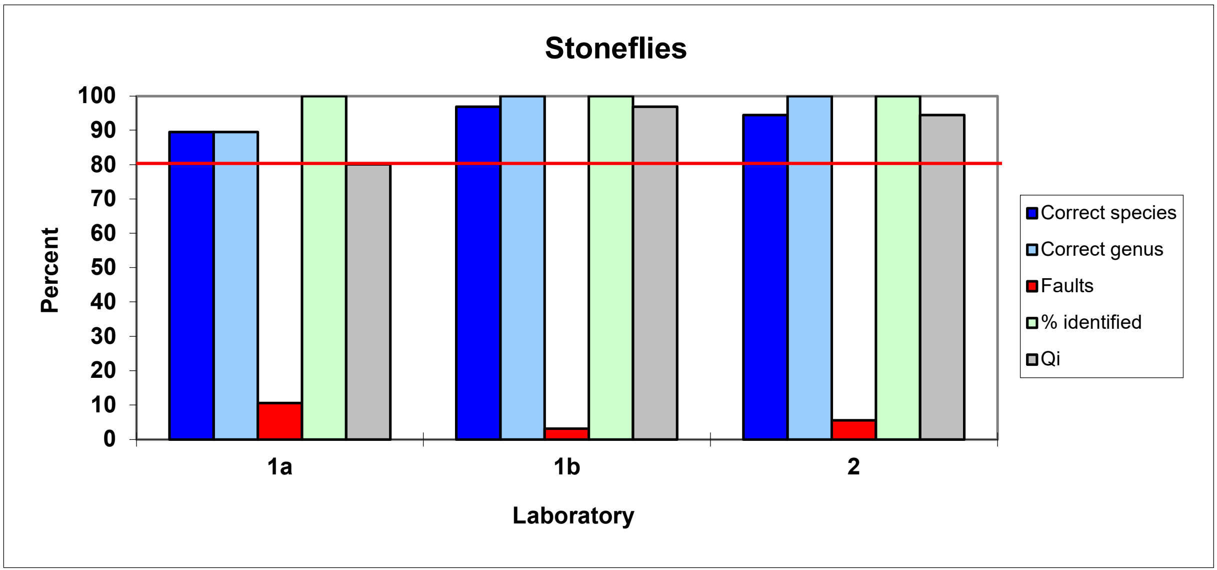

Figure 4. Results from the identification of stoneflies. The red line indicates the limit for good taxonomic work.

Caddisflies (Trichoptera)

Laboratory 2 was flawless on the identification of caddisflies (Figure 5). Laboratory 1a and 1b initially misidentified one species of trichoptera when making the initial sample.

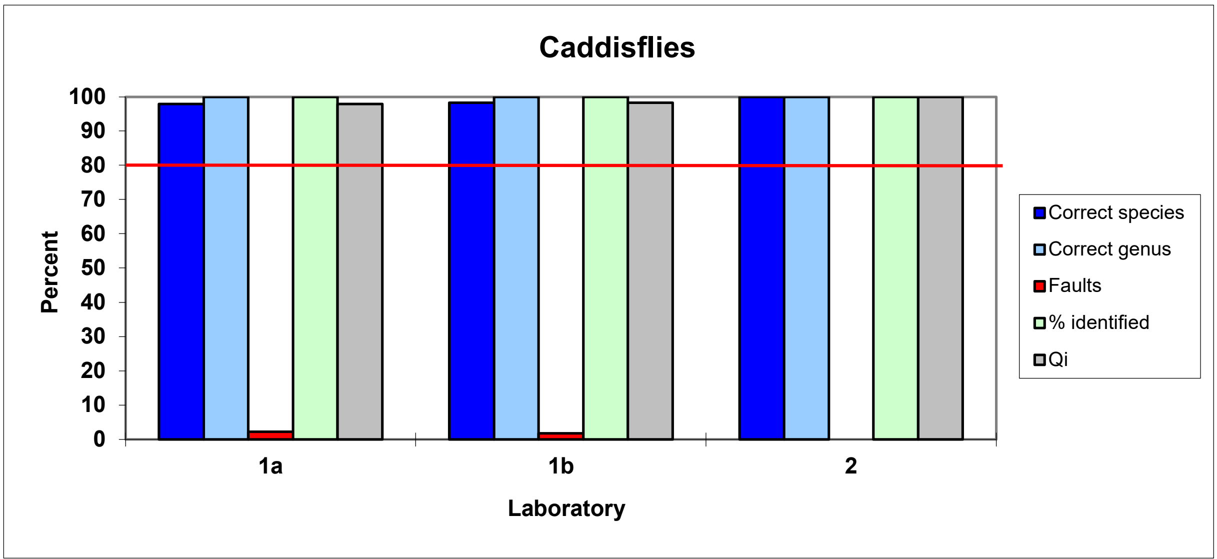

Figure 5. Results from the identification of caddisflies. The red line indicates the limit for good taxonomic work.

Miscellaneous

Lab 1a and 2 both identified 100% of the species in their samples (Figure 6). Lab 1b misidentified two individuals at species level but were still above the acceptable limit. One of these was the larvae of the genus Olimnius.

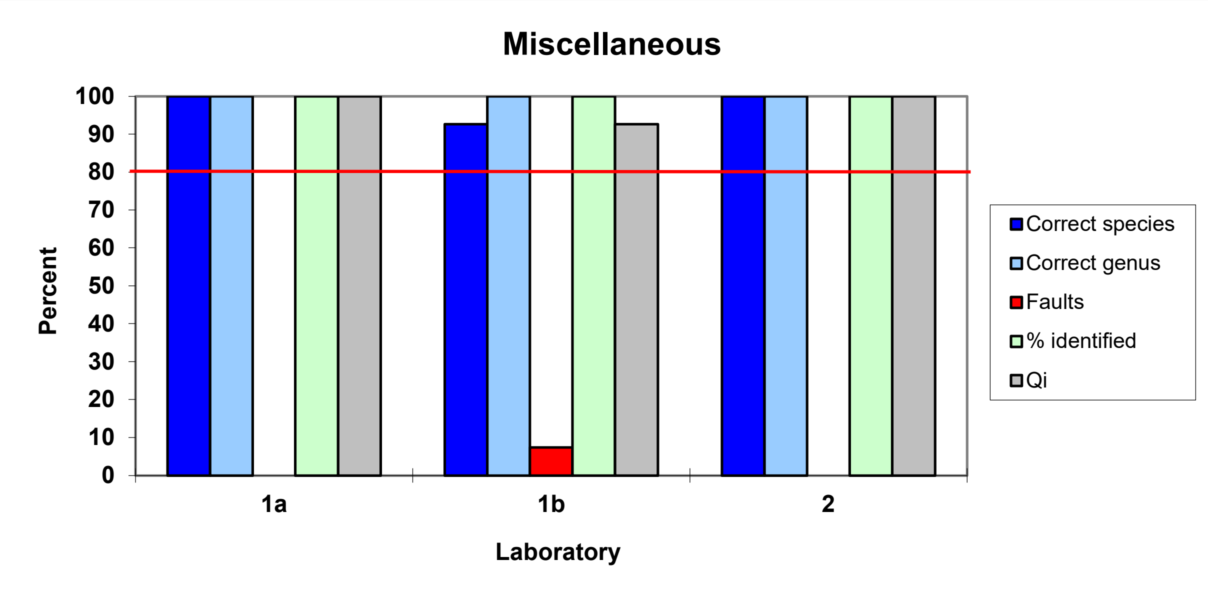

Figure 6. Results from the identification of miscellaneous groups of invertebrates. The red line indicates the limit for good taxonomic work.

Total number of species in the sample

A total of 265 individuals were sent to the laboratories. Laboratory 1 received a total of 85 individuals while laboratory 1b and 2 received 90 individuals. Of these, all specimens were reported to the Programme subcentre.

4 Evaluation

The laboratories correctly identified a high proportion of the total number of species in the test samples with a mean Qi-score at 3.9 points above the average from the previous 25 years, and 16.0 points over the acceptable limit. The mean taxonomic skill per laboratory is shown in Figure 7. The mean Qi was 93.3 for laboratory 1a, 97.4 for laboratory 1b and 97.4 for laboratory 2. All laboratories were well above the acceptable limit of 80.0 and above the average of 92.1 from the previous 25 years.

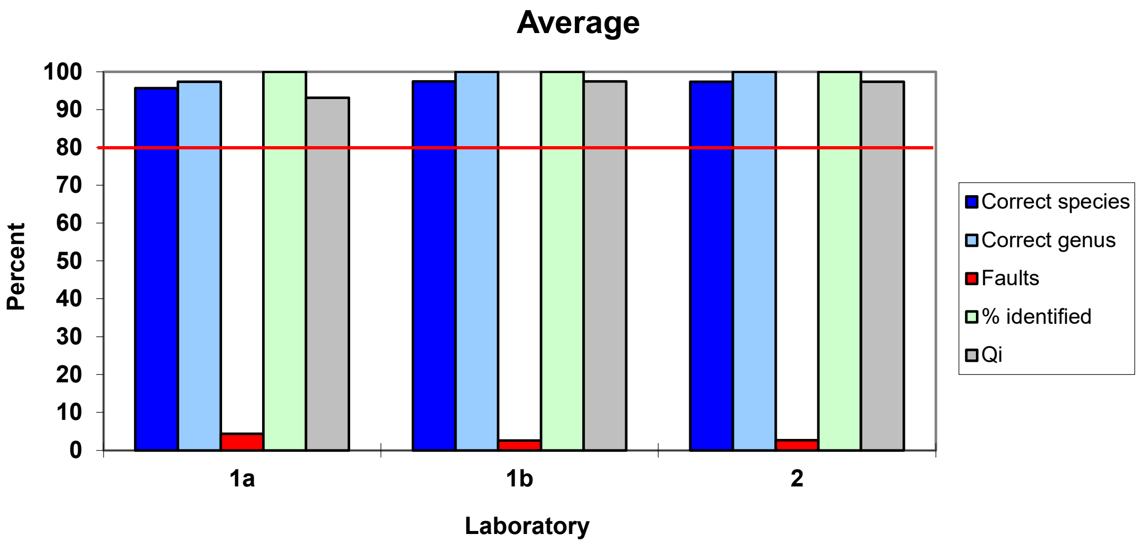

Figure 7. Mean skill in percent of identifying species and genus, and mean Qi for each laboratory. The red line indicates the acceptable limit.

The lowest mean Qi- score for the intercalibration in 2021 was in the group of plecoptera with a score of 90.5%, while the highest mean score was from the trichoptera group with 98.7%. This reflects a trend seen over the last 25 years with higher skills in identifying species of trichoptera than species of plecoptera. Still, the scores for both groups in 2021 were higher than the average score from the 25 years of intercalibration.

The biological intercalibration is important for harmonizing biological material/databases and will be of high value in projects that focus on community analyses, or where the ecological status of waterbodies should be determined. The biological intercalibration under the ICP Waters programme was the first regular test aiming to test taxonomic skills in identifying benthic invertebrates. Today, similar tests are run by the North American Benthological Society (http://www.nabstcp.com) and by the Natural History museum, London (Identification Qualifications – IdQ test). The invertebrate groups covered in the latter test are those used in the BMWP water quality score system (Armitage et al., 1983) and include groups used for monitoring freshwater environments under the EU Water Framework Directive (Schartau et al. 2008). In 2017-2018, NORCE also organized an intercalibration for Norwegian laboratories that identify benthic invertebrates on a regular basis. The results from the Norwegian test showed that the participants found a significantly different number of species and a significantly different species composition, despite identifying identical samples (Velle et al. 2018). The differences resulted in a classification of ecological status that to some extent was person dependent. These results highlight the importance of quality assurance and coordination of species identifications.

Because of the results of the intercalibration in Norway, regular intercalibrations will be performed in the future. Also, the Norwegian Environment Agency use participations in intercalibrations as part of the evaluation criteria when assigning companies to new projects (Velle et al. 2020).

5 Trends over time

The invertebrate intercalibration in ICP Waters started in 1992. An overall high of 11 laboratories participated during the first intercalibration (Figure 8). Since then, the average has been just under five participants per year. Twenty laboratories from 17 countries have participated over the years, including Austria, Belgium, Canada, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Latvia, Norway, Russia, Sweden, Switzerland and UK. This year, two laboratories participated in the intercalibration with three taxonomists participating in total. Several new laboratories have shown interest in participating in 2022. In 2021 two laboratories were tested, however one laboratory was tested twice due to a delay in delivery of the sample. Consequentially, this lab was tested twice with two different taxonomists and therefore, both their results are included in the report but remain as one laboratory when counting number of participants.

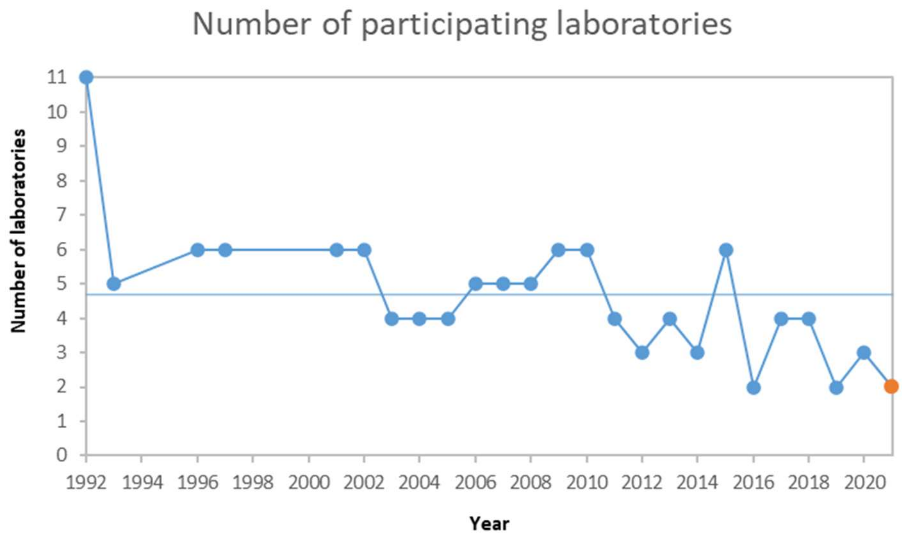

Figure 8. The number of participating laboratories in the ICP Waters invertebrate intercalibration since the first intercalibration in 1992. The number of participants in 2021 are shown in red.

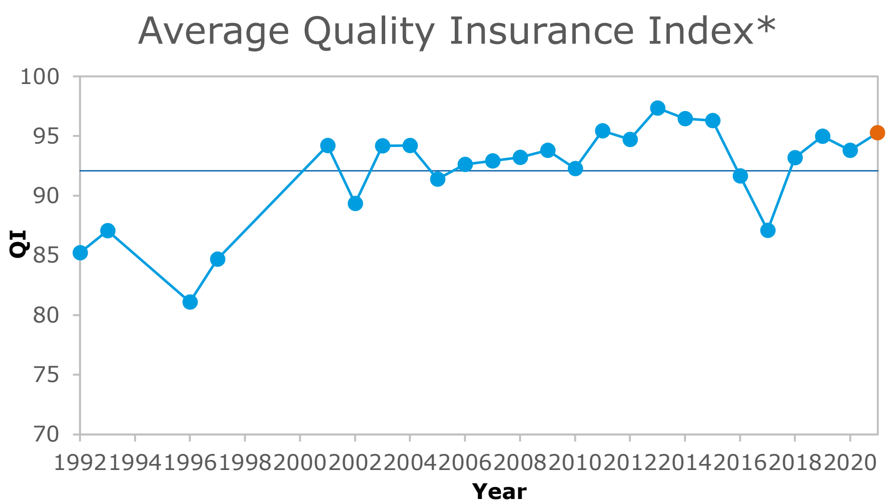

Figure 9. The mean quality assurance index for the invertebrate intercalibration through time. The horizontal line represents the mean QI for the last 29 years. Results from 2021 are shown in red.

The intercalibration laboratory protocol is unchanged since 1992, while the quality assurance index (Qi) has been used since it was introduced in 2005 (Raddum, 2005). After back calculating the Qi for the period prior to 2005 the Qi now is available from 1992 and up to the present (Figure 9). Trends in the Qi-score show that the mean has remained above 80%, suggesting good taxonomic work and skilled taxonomists in the laboratories affiliated to ICP Waters. When the Qi is broken into individual invertebrate groups, it is clear that the laboratories, on average over the years, perform best for caddisflies and worst for stoneflies (Figure 10). As with previous years, the laboratories scored slightly worse for the stoneflies suggesting that laboratories could still benefit from focusing on this group in the future.

One of the aims of the intercalibration is to improve the taxonomic skill of the participating laboratories. The mean Qi has increased since the intercalibration started, suggesting that the skills have improved (Figure 9). Still, at least four issues influence the Qi:

1) The Qi varies according to the skills of the participants. A consequence is that the Qi often decreases when new labs participate or if a skilled taxonomist retires. As an example, the expert on the miscellaneous group retired from laboratory 2 in 2018, which resulted in a low Qi.
2) The Qi varies according to the difficulty of the test, which mostly depends on the size of the specimen and the rarity of the species. For example, more species in the miscellaneous group were included in the intercalibration around 2005 since new acidification indices demanded a higher taxonomic resolution for this group. Hence, the Qi subsequently dropped for some years before it gradually increased (Figure 10). The increase likely reflects improved taxonomic skill.
3) There is inevitably some chance involved. For example, samples have occasionally dried out, a taxonomist may have overlooked a specimen or forgotten to make comments on a damaged specimen.
4) Some years, the participants send too few specimens from their home region to the intercalibration organizer. This may influence the results since the organizer then needs to include specimen from other regions to the test of that specific participant. It is therefore important that the participants send an abundance of specimens to the organizer.
5) The mean Qi is calculated as the average of the scores from each taxonomic group. The Qi-score for each group is calculated from the percentage of errors made in the group. This means that a taxonomic error in a group with few individuals will have a larger negative impact on the Qi-score than an error in a group with many individuals.

The mean Qi has decreased during 2012-2017, more steeply between 2015 and 2017, to increase again towards the present. According to the taxonomists, the difficulty increased during 2015-2017, and especially for stoneflies. In addition, it seems that some other above-mentioned factors apply; there was a new participant, one key taxonomist retired, one sample dried out and one laboratory sent too few specimens from their home region. Hopefully, the abundance of such events will decline during forthcoming intercalibrations. The mean Qi for 2021 slightly increased from 2020 following the upwards trend since 2018.

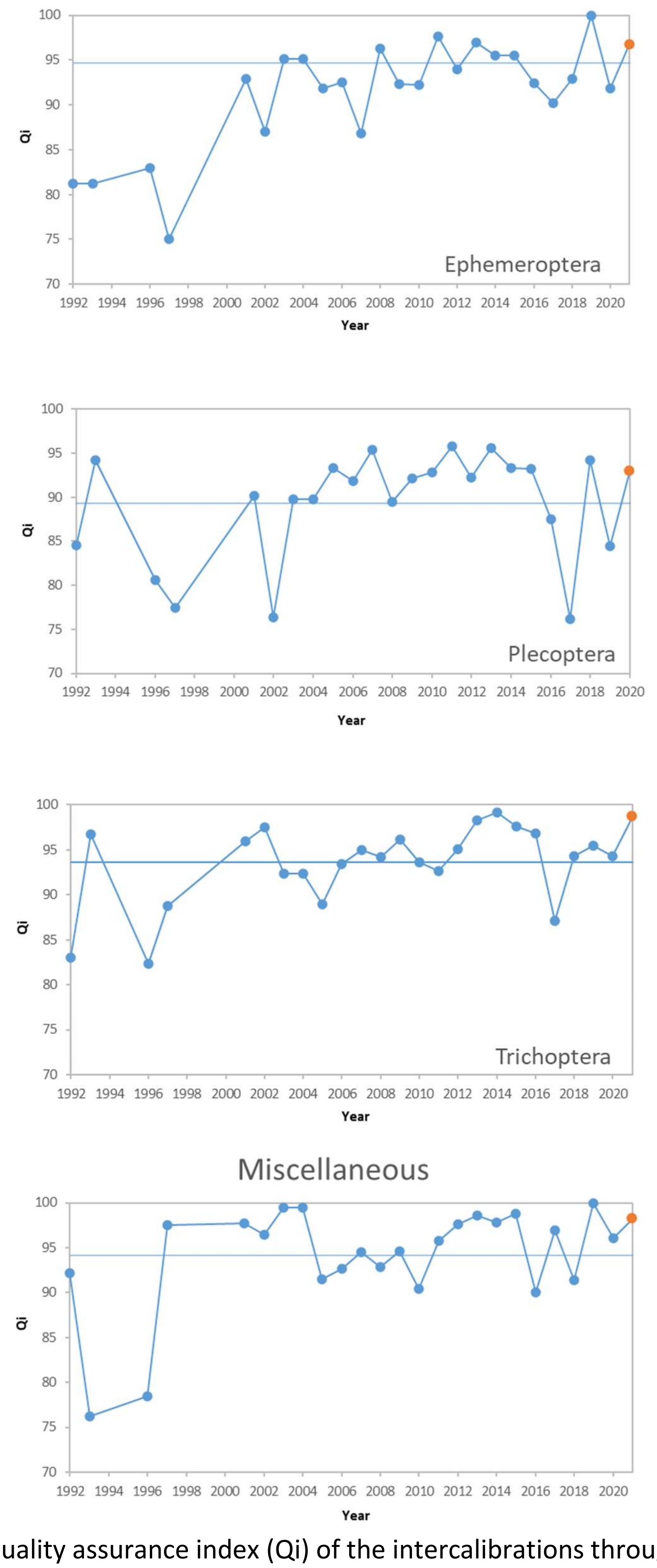

Figure 10. The mean quality assurance index (Qi) of the intercalibrations through time for mayflies (Ephemeroptera), stoneflies (Plecoptera), caddisflies (Trichoptera) and miscellaneous groups of invertebrates. The horizontal line represents the overall mean Qi for each invertebrate group. The red marker indicates results from 2021. Qi above 80 is regarded as good and thus acceptable taxonomical work.

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Appendix A. Responsible laboratories

Each participating laboratory is identified by a number, which is identical with laboratory numbers in the report and Appendix B. Laboratories participating in the intercalibration of invertebrates in 2021 are:

1.
    a. Estonian Environmental Research Centre, Tartu Department, Vaksali 17a, 50419 Tartu, **Estonia**. Responsible taxonomists: Dr. Lilian Matsavas.
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Appendix B. Species lists

Table B. 1. Identified species/genus in sample 1 and 2 by laboratory 1a

	Sample 1		Sample 2	
	Delivered	**Identified**	**Delivered**	**Identified**
Ephemenoptera				
Arthroplea congener	1	1		
Baetis digitatus	1	1		
Nigrobaetis niger	1	1	1	1
Baetis buceratus	1	1		
Centroptilum luteolum	1	1		
Ephemerella mucronata	1	1		
Ephemera danica	1	1		
Kageronia fuscogrisea	1	1		
Paraleptophlebia submarginata	1	1		
Siphlonurus aestivalis	1	1		
Baetis vernus			1	1
Baetis fuscatus			1	1
Baetis rhodani			1	1
Alainites muticus			1	1
Ephemera vulgata			1	1
Lephtophlebia marginata			1	1
Harbophlebia lauta			1	
Caenis rivulorum			1	1
Heptagenia sulphurea			1	1
Heptagenia flava			1	1
Plecoptera				
Capnia bifrons	1	1	1	1
Nemoura flexuosa	1	1		
Protonemura intricata	1	1		
Perlodes dispar	1	1		
Taeniopteryx nebulosa	1	1		
Diura nanseni	1	1		
Isoperla difformis	1	1		
Rhabdiopteryx acuminata	1	1		
Amphinemura borealis	1	1	1	1
Leuctra fusca			1	1
Leuctra hippopus			1	1
Nemurella pictetii			1	1
Capnopsis schilleri			1	1
Nemoura cinerea			1	1
Nemoura avicularis			1	1

	Sample 1		Sample 2	
	Delivered	**Identified**	**Delivered**	**Identified**
Isoperla grammatica			1	
Brachyptera risi			1	
Trichoptera				
Athripsodes aterrimus	1	1		
Ceraclea annulicornis	1	1		
Lepidostoma hirtum	1	1		
Anabolia laevis & furcata	1	1		
Glyphotaelius pellucidus	1	1		
Halesus radiatus	1	1		
Rhyacophila nubila	1	1		
Limnephilus rhombicus	1	1		
Ironoquia dubia	1	1	1	1
Molanna angustata	1	1		
Polycentropus flavomaculatus	1	1	1	1
Hydatophylax infumatus			1	1
Limnephilus subcentralis			1	1
Potampophylax latipennis			1	1
Potamophylax rotundipennis			1	1
Phryganea bipunctata			1	1
Cyrnus trimaculatus			2	2
Neureclipsis bimaculata			1	1
Anabolia nervosa			1	
Rhyacophila fasciata			1	1
Sericostoma personatum			1	1
Coleoptera				
Acilius canaliculatus	1	1		
Hyphydrus ovatus	1	1		
Nebrioporus depressus	1	1		
Brychius elevatus			1	1
Ilybous fuliginosus			1	1
Elmis maugetii			1	1
Olimnius tuberculatus			1	1
Risolus cupreus			1	1
Diptera				
Atherix ibis	1	1		
Antocha vitripennis			1	1
Gastropda:				
Theodoxus fluviatilis	1	1	1	1
Heteroptera				
Sigara falleni (corixidae)	1	1		
Aquarius najas (Gerridae)	1	1		

	Sample 1		Sample 2	
	Delivered	**Identified**	**Delivered**	**Identified**
Notonecta glauca			1	1
Gerris lacustris			1	1
Hirudinea				
Hemiclepsis marginata	1	1		
Helobdella stagnalis			1	1
Glossiphonia complanata			1	1
Odonata				
Somatochlora metallica (Corduliidae)	1	1		
Brachytron pratense			1	1
Megaloptera				
Sialis fuliginosa			1	1

Table B. 2. Identified species/genus in sample 1 and 2 by laboratory 1b

	Sample 1		Sample 2	
	Delivered	**Identified**	**Delivered**	**Identified**
Ephemenoptera				
Baetis vernus	1	1		
Nigrobaetis niger	1	1	1	1
Baetis buceratus	1	1		
Baetis fuscatus	1	1		
Kageronia fuscogrisea	1	1		
Siphlonurus aestivalis	1	1		
Ephemera danica	1	1		
Ephemerella mucronata	1	1		
Paraleptophlebia submarginata			2	2
Centroptilum luteolum			1	1
Baetis digitatus			1	1
Alainites (Baetis) muticus			1	1
Baetis rhodani			1	1
Caenis luctuosa			1	1
Ephemera vulgata			1	1
Plecoptera				
Taeniopteryx nebulosa	1	1	1	1
Rhabdiopteryx acuminata	1	1	1	1
Protonemura intricata	1			
Nemoura flexuosa	1	1		
Amphinemura borealis	1	1	1	1
Capnia bifrons	1	1		
Nemoura avicularis	1	1		
Isoperla difformis			1	1
Isoperla grammatica			1	1
Nemoura cinerea			1	1
Leuctra hippopus			1	1
Siphonoperla burmeisteri			1	1
Capnopsis schilleri			1	1
Trichoptera				
Neureclipsis bimaculata	1	1		
Polycentropus flavomaculatus	1	1		
Potamophylax rotundipennis	1	1		
Halesus radiatus	1	1		
Anabolia nervosa	1			
Athripsodes aterrimus	1	1		
Ceraclea annulicornis	1	1	1	1
Sericostoma personatum	1	1		
Rhyacophila fasciata	1	1		

	Sample 1		Sample 2	
	Delivered	Identified	Delivered	Identified
Phryganea grandis	1	1		
Plectrocnemia conspersa	1	1		
Holocentropus dubius	1	1		
Micrasema setiferum	1	1		
Hydropsyche contubernalis	1	1		
Anabolia laevis&furcata			1	1
Hydropsyche pellucidula			1	1
Oligostomis reticulata			1	1
Limnephilus rhombicus			1	1
Hydropsyche angustipennis			1	1
Potamophylax latipennis			1	1
Brachycentrus subnubilus			1	1
Cheumatopsyche lepida			1	1
Rhyacophila nubila			1	1
Hydropsyche siltalia			1	1
Lepidostoma hirtum			1	1
Molannodes tinctus			1	1
Holocentropus picicornis			1	1
Agrypnia pagetana			1	1
Megaloptera				
Sialis fuliginosa	1	1		
Sialis sordida			1	1
Gastropoda				
Theodoxus fluviatilis	1	1		
Bithynia tentaculata	1	1	1	1
Lymnaea stagnalis			1	1
Physa fontinalis			1	1
Hirudinea				
Erpobdella octoculata	1	1		
Dina lineata			1	1
Odonata				
Platycnemis pennipes	1	1		
Calopteryx virgo	1			
Onyochgomphus forcipatus			1	1
Coleoptera				
Olimnius tuberculatus	2	2		
Normandia nitens	1	1		
Riolus cupreus	1	1		
Elmis aenea	1	1		
Limnius volckmari	1	1	1	1
Elmis maugetii			1	1

	Sample 1		Sample 2	
	Delivered	**Identified**	**Delivered**	**Identified**
Laccophilus hyalinus			1	1
Diptera				
Antocha vitripennis	1	1		
Atherix ibis			1	1
Malacostraca				
Gammarus pulex	1	1		
Pontogammarus robustoides	1	1		
Asellus aquaticus			1	1
Lepidoptera				
Parapoynx stratiotata			1	1

Table B. 3. Identified species/genus in sample 1 and 2 by laboratory 2

	Sample 1		Sample 2	
	Delivered	**Identified**	**Delivered**	**Identified**
Ephe:				
Arthroplea congener	1	1		
Leptophlebia marginata	1	1		
Caenis luctuosa	1	1		
Caenis rivulorum	1	1	1	1
Baetis rhodani	1		1	1
Ephemera vulgata	1	1		
Ephemerella ignita	1	1	1	1
Heptagenia sulphurea	1	1		
Kageronia (Heptag.)fuscogrisea	1	1	1	1
Ameletus inopinatus	1		1	1
Leptophlebia vespertina			1	1
Alainites (Baetis) muticus			1	1
Caenis horaria			1	1
Centroptilum luteolum			1	1
Baetis digitatus			1	1
Plecoptera				
Siphonoperla burmeisteri	1	1	1	1
Amphinemura borealis	1	1		
Nemoura flexuosa	1	1		
Leuctra nigra	1	1	1	
Nemoura avicularis	1	1	1	1
Diura nanseni	1	1	1	1
Dinocras cephalotes	1	1	1	1
Nemoura cinerea	1	1		
Protonemura meyeri	1	1		
Brachyptera risi			1	1
Amphinemura sulcicollis			1	1
Leuctra fusca			1	1
Capnopsis schilleri			1	1
Trichoptera				
Oecetis testacea	1	1		
Athripsodes cinereus	1	1		
Athripsodes aterrimus	1	1	1	1
Neureclipsis bimaculata	1	1	1	1
Molannodes tinctus	1	1		
Philopotamus montanus	1	1	1	1
Lepidostoma hirtum	1	1		
Sericostoma personatum	1	1	1	1
Hydropsyche pellucidula	1	1		

	Sample 1		Sample 2	
	Delivered	**Identified**	**Delivered**	**Identified**
Micrasema setiferum	1	1	1	1
Glossosoma intermedium	1	1		
Ceraclea annulicornis	1	1		
Ecnomus tenellus	1	1		
Cheumatopsyche lepida	1	1		
Setodes argentipunctellus			1	1
Crunoechia irrorata			1	1
Molanna angustata			1	1
Holocentropus picicornis			1	1
Cyrnus insolutus			1	1
Hydropsyche siltalai			1	1
Mystacides azurea			1	1
Arctopsyche ladogensis			1	1
Ironoquia dubia			1	1
Apatania wallengreni			1	1
Coleoptera				
Elmis aenea	1	1	1	1
Stenelmis canaliculata	1	1	1	1
Nebriporus depressus	1	1		
Laccophilus hyalinus	1	1		
Normandia nitens			2	2
Diptera				
Chaoborus flavicans	1	1	1	1
Tipula sp.	1	1		
Dicranota sp.			1	1
Malacostraca				
Monoporeia affinis	1	1		
Gammarus pulex			1	1
Asellus aquaticus			1	1
Gastropoda				
Gyraulus albus			1	1
Gyraulus acronicus			1	1
Radix balthica			1	1
Physa fontinalis			1	1
Bithynia tentaculata			1	1
Hirudinea				
Erpobdella testacea	1	1		
Megaloptera				
Sialis lutaria	1	1		
Hemiptera				
Ilyocoris cimicoides	1	1		

	Sample 1		Sample 2	
	Delivered	**Identified**	**Delivered**	**Identified**
Odonata				
Cordulegaster boltoni	1	1		

Appendix C. Reports and publications from the ICP Waters programme

All reports from the ICP Waters programme from 2000 up to present are listed below. Reports before year 2000 can be listed on request. All reports are available from the Programme Centre. Reports and recent publications are also accessible through the ICP Waters website; http://www.icp-waters.no/

Bryntesen, T. 2021. Intercomparison 2135: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Tot-P, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA report SNO 7681-2021. **ICP Waters report 147/2021.**

Thrane, J.E., de Wit, H. and Austnes, K. 2021. Effects of nitrogen on nutrient-limitation in oligotrophic northern surface waters. NIVA report SNO 7680-2021. **ICP Waters report 146/2021.**

Garmo, Ø., Furuseth, I.S., and Austnes, K. (editors) 2021. Proceedings of the 37th Task Force meeting of the ICP Waters Programme held on-line, April 28-29, 2021. NIVA report SNO 7657-2021. **ICP Waters report 145/2021**

Velle, G., Birkeland, I.B., Johannessen, A. and Landås, T.S. 2020. Biological intercalibration: Invertebrates 2020. NIVA SNO 7556-2020. **ICP Waters report 144/2020**

Gundersen, C.B. and Bryntesen, T. 2021. Intercomparison 2034: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Tot-P, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA SNO 7621-2021. **ICP Waters report 143/2021.**

Gundersen, C.B. 2020. Intercomparison 2034: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Tot-P, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA SNO 7549-2020. **ICP Waters report 143/2020.** *Obs! This report has been revised (see ICP Waters 143/2021 above).*

Garmo, Ø., Arle, J., Austnes, K. de Wit, H., Fölster, J., Houle, D., Hruška, J., Indriksone, I., Monteith, D., Rogora, M., Sample, J.E., Steingruber, S., Stoddard, J.L., Talkop, R., Trodd, W., Ulańczyk, R.P. and Vuorenmaa, J. 2020. Trends and patterns in surface water chemistry in Europe and North America between 1990 and 2016, with particular focus on changes in land use as a confounding factor for recovery. NIVA report SNO 7479-2020. **ICP Waters report 142/2020**

Gundersen, C.B. 2019. Intercomparison 1933: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Tot-P, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA SNO 7445-2019. **ICP Waters report 141/2019.**

Velle, G., Birkeland, I.B., Johannessen, A. and Landås, T.S. 2019. Biological intercalibration: Invertebrates 2019. NIVA SNO 7433-2019. **ICP Waters report 140/2019**

Garmo, Ø., Austnes, K. and Vuorenmaa, J. (editors) 2019. Proceedings of the 35th Task Force meeting of the ICP Waters Programme in Helsinki, June 4-6, 2019. NIVA report SNO 7437-2019. **ICP Waters report 139/2019**

Velle, G., Johannessen, A. and Landås, T.S. 2018. Biological intercalibration: Invertebrates 2018. NIVA report SNO 7314-2018. **ICP Waters report 138/2018**

Escudero-Oñate, C. 2018. Intercomparison 1832: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Tot-P, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA report SNO 7316-2018. **ICP Waters report 137/2018.**

Garmo, Ø., Ulańczyk, R. and de Wit, H. (eds.) 2018. Proceedings of the 34th Task Force meeting of the ICP Waters Programme in Warsaw, May 7-9, 2018. NIVA report SNO 7298-2018. **ICP Waters report 136/2018.**

Austnes, K. Aherne, J., Arle, J., Čičendajeva, M., Couture, S., Fölster, J., Garmo, Ø., Hruška, J., Monteith, D., Posch, M., Rogora, M., Sample, J., Skjelkvåle, B.L., Steingruber, S., Stoddard, J.L., Ulańczyk, R., van Dam, H., Velasco, M.T., Vuorenmaa, J., Wright, R.F., de Wit, H. 2018. Regional assessment of the current extent of acidification of surface waters in Europe and North America. NIVA report SNO 7268-2018. **ICP Waters report 135/2018**

Escudero-Oñate, C. 2017. Intercomparison 1731: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA report SNO7207-2017. **ICP Waters report 134/2017**.

Halvorsen, G.A., Johannessen, A. and Landås, T.S. 2017. Biological intercalibration: Invertebrates 2017. NIVA report SNO 7198-2017. **ICP Waters report 133/2017**.

Braaten, H.F.V., Åkerblom, S., de Wit, H.A., Skotte, G., Rask, M., Vuorenmaa, J., Kahilainen, K.K., Malinen, T., Rognerud, S., Lydersen, E., Amundsen, P.A., Kashulin, N., Kashulina, T., Terentyev, P., Christensen, G., Jackson-Blake, L., Lund, E. and Rosseland, B.O. 2017. Spatial and temporal trends of mercury in freshwater fish in Fennoscandia (1965-2015). NIVA report SNO 7179-2017. **ICP Waters report 132/2017**.

Garmo, Ø., de Wit, H. and Fölster, J. (eds.) 2017. Proceedings of the 33rd Task Force meeting of the ICP Waters Programme in Uppsala, May 9-11, 2017. NIVA report SNO 7178-2017. **ICP Waters report 131/2017**.

Halvorsen, G.A, Johannessen, A. and Landås, T.S. 2016. Biological intercalibration: Invertebrates 2016. NIVA report SNO 7089-2016. **ICP Waters report 130/2016**.

Escudero-Oñate, C. 2016. Intercomparison 1630: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni and Zn. NIVA report SNO 7081-2016. **ICP Waters report 129/2016.**

De Wit, H. and Valinia, S. (eds.) 2016. Proceedings of the 32st Task Force meeting of the ICP Waters Programme in Asker, Oslo, May 24-26, 2016. NIVA report SNO 7090-2016. **ICP Waters report 128/2016**.

Velle, G., Mahlum, S., Monteith, D.T., de Wit, H., Arle, J., Eriksson, L., Fjellheim, A., Frolova, M., Fölster, J., Grudule, N., Halvorsen, G.A., Hildrew, A., Hruška, J., Indriksone, I., Kamasová, L., Kopáček, J., Krám, P., Orton, S., Senoo, T., Shilland, E.M., Stuchlík, E., Telford, R.J., Ungermanová, L., Wiklund, M.-L. and Wright, R.F. 2016. Biodiversity of macro-invertebrates in acid-sensitive waters: trends and relations to water chemistry and climate. NIVA report SNO 7077-2016. NIVA report SNO 7077-2016. **ICP Waters report 127/2016**.

De Wit, H., Valinia, S. and Steingruber, S. 2015. Proceedings of the 31st Task Force meeting of the ICP Waters Programme in Monte Verità, Switzerland 6th –8th October, 2015. NIVA report SNO 7003-2016. **ICP Waters report 126/2015**.

De Wit, H., Hettelingh, J.P. and Harmens, H. 2015. Trends in ecosystem and health responses to long-range transported atmospheric pollutants. NIVA report SNO 6946-2015. **ICP Waters report 125/2015**.

Fjellheim, A., Johannessen, A. and Landås, T.S. 2015. Biological intercalibration: Invertebrates 1915. NIVA report SNO 6940-2015. **ICP Waters report 124/2015**.

Escudero-Oñate, C. 2015 Intercomparison 1529: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA report SNO 6910-2015. **ICP Waters report 123/2015**.

de Wit, H., Wathne, B. M. (eds.) 2015. Proceedings of the 30th Task Force meeting of the ICP Waters Programme in Grimstad, Norway 14th –16th October, 2014. NIVA report SNO 6793-2015. **ICP Waters report 122/2015**.

Fjellheim, A., Johannessen, A. and Landås, T.S. 2014. Biological intercalibration: Invertebrates 1814. NIVA report SNO 6761-2014. **ICP Waters Report 121/2014**.

Escuedero-Oñate. 2014. Intercomparison 1428: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA report SNO 6718-2014. **ICP Waters Report 120/2014**.

De Wit, H. A., Garmo Ø. A. and Fjellheim A. 2015. Chemical and biological recovery in acid-sensitive waters: trends and prognosis. **ICP Waters Report 119/2014**.

Fjellheim, A., Johannessen, A. and Landås, T.S. 2013. Biological intercalibration: Invertebrates 1713. NIVA report SNO 6662-2014. **ICP Waters Report 118/2014**.

de Wit, H., Bente M. Wathne, B. M. and Hruśka, J. (eds.) 2014. Proceedings of the 29th Task Force meeting of the ICP Waters Programme in Český Krumlov, Czech Republic 1st –3rd October, 2013. NIVA report SNO 6643-2014. **ICP Waters report 117/2014**.

Escuedero-Oñate, C. 2013. Intercomparison 1327: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni and Zn. NIVA report SNO 6569-2013. **ICP Waters Report 116/2013**.

Holen, S., R.F. Wright and Seifert, I. 2013. Effects of long-range transported air pollution (LTRAP) on freshwater ecosystem services. NIVA report SNO 6561-2013. **ICP Waters Report 115/2013**.

Velle, G., Telford, R.J., Curtis, C., Eriksson, L., Fjellheim, A., Frolova, M., Fölster J., Grudule N., Halvorsen G.A., Hildrew A., Hoffmann A., Indriksone I., Kamasová L., Kopáček J., Orton S., Krám P., Monteith D.T., Senoo T., Shilland E.M., Stuchlík E., Wiklund M.L., de Wit, H. and Skjelkvaale B.L. 2013. Biodiversity in freshwaters. Temporal trends and response to water chemistry. NIVA report SNO 6580-2013. **ICP Waters Report 114/2013**.

Fjellheim, A., Johannessen, A. and Landås, T.S. 2013. Biological intercalibration: Invertebrates 1612. **ICP Waters Report 113/2012**.

Skjelkvåle, B.L., Wathne, B.M., de Wit, H. and Rogora, M. (eds.) 2013. Proceedings of the 28th Task Force meeting of the ICP Waters Programme in Verbania Pallanza, Italy, October 8 – 10, 2012. NIVA report SNO 6472-2013. **ICP Waters Report 112/2013**.

Dahl, I. 2012. Intercomparison 1226: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni and Zn. NIVA report SNO 6412-2012. **ICP Waters report 111/2012**.

Skjelkvåle, B.L., Wathne B. M. and Moiseenko, T. (eds.) 2012. Proceedings of the 27th meeting of the ICP Waters Programme Task Force in Sochi, Russia, October 19 – 21, 2011. NIVA report SNO 6300-2012. **ICP Waters report 110/2012**.

Fjellheim, A., Johannessen, A., Svanevik Landås, T. 2011. Biological intercalibration: Invertebrates 1511. NIVA report SNO 6264-2011. **ICP Waters report 109/2011**.

Wright, R.F., Helliwell, R., Hruska, J., Larssen, T., Rogora, M., Rzychoń, D., Skjelkvåle, B.L. and Worsztynowicz, A. 2011. Impacts of Air Pollution on Freshwater Acidification under Future Emission Reduction Scenarios; ICP Waters contribution to WGE report. NIVA report SNO 6243-2011. **ICP Waters report 108/2011**.

Dahl, I and Hagebø, E. 2011. Intercomparison 1125: pH, Cond, HCO3, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA report SNO 6222-2011. **ICP Waters report 107/2011**.

Skjelkvåle B.L. and de Wit, H. (eds.) 2011. Trends in precipitation chemistry, surface water chemistry and aquatic biota in acidified areas in Europe and North America from 1990 to 2008. NIVA report SNO 6218-2011. **ICP Waters report 106/2011**.

ICP Waters Programme Centre 2010. ICP Waters Programme manual. NIVA SNO 6074-2010. **ICP Waters report 105/2010**.

Skjelkvåle, B.L., Wathne B. M. and Vuorenmaa J. (eds.) 2010. Proceedings of the 26th meeting of the ICP Waters Programme Task Force in Helsinki, Finland, October 4 – 6, 2010. NIVA report SNO 6097-2010. **ICP Waters report 104/2010**.

Fjellheim, A. 2010. Biological intercalibration: Invertebrates 1410. NIVA report SNO 6087-2010. NIVA report SNO 6087-2010. **ICP Waters report 103/2010**.

Hovind, H. 2010. Intercomparison 1024: pH, Cond, HCO_3, NO_3-N, Cl, SO_4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA report SNO 6029-2010. **ICP Waters report 102/2010**.

De Wit, H.A. and Lindholm M. 2010. Nutrient enrichment effects of atmospheric N deposition on biology in oligotrophic surface waters – a review. NIVA report SNO 6007 - 2010. **ICP Waters report 101/2010**.

Skjelkvåle, B.L., De Wit, H. and Jeffries, D. (eds.) 2010. Proceedings of presentations of national activities to the 25th meeting of the ICP Waters Programme Task Force in Burlington, Canada, October 19-21 2009. NIVA report SNO 5995 - 2010. **ICP Waters report 100/2010**.

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